PAPER

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ANALYSIS OF COCONUT SHELL CHARCOAL POWDER COMPOSITES WITH THE PVAC GLUE TO THE IMPACT, BENDING AND SOUND ABSORPTION FOR ACOUSTICS WALL APPLICATION

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ANALYSIS OF COCONUT SHELL CHARCOAL POWDER COMPOSITES WITH THE PVAC GLUE TO THE IMPACT, BENDING AND SOUND ABSORPTION FOR ACOUSTICS WALL APPLICATION

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Abstract

The aims from this study are determine the impact strength of composite and determine the bending strength of composite coconut shell charcoal and then find out the sound absorption power of coconut shell charcoal composite.

In the manufacture of composite materials using coconut shell powder with an average diameter 11.89 μm. on 8-10 % of water level and PVAC matrix glue. The volume of fraction of composites there are 40%. 50%, 60%, and pressed the composites by using press mold method that is tightening the bolt on the mold. The test were conducted to ASTM and ANSI standards. For impact test conducted to ASTM D256-00, for bending test conducted to ASTM 790 and for sound absorption test conducted to ANSI SI13 by using five second method with one minutes for reading time.

Value of impact result revealed that the highest average at 40% fraction of 0.0100 j/mm^2 with 1.328 j of energy absorption and the lowest at 60% fraction of 0.0063 j/mm^2 with energy absorbing o.885 j. Value of highest bending strength at 40% fraction is 0.62 MPa to 55.66 MPa modulus elasticity, whereas for bending strength the lowest result on fraction 60% that is 0.38 MPa with 22.25 MPa of modulus elasticity. For sound absorption capability of composites resulted by fraction 60% that is 3.28 dB while sound absorption capability of composites coated (sponge and plywood) resulted by fraction 60% that is 13.12 dB.

Keywords: composite, coconut shell charcoal powder, sound absorption

INTRODUCTION

1.1 Background

In the development of industry today, the use and utilization of materials has more and more enthusiasts lately. As time goes by the increasing of material using which is increasingly expanding range from as simple as the craftsman tools house hold furnishings to industry sectors, either intermediate industry down and up. Composite has its own advantages compared with other alternative materials, such as the material is easy to obtain, easy to manufacture, powerful, lightweight, corrosion resistant and economical.

Pick up from the background of problem above, so the researcher makes a breakthrough or innovation in applying of waste from coconut shell formed into charcoal to make coconut shell charcoal composite material as damper sound wall.

Literatures Review

Wicaksono Prio (2011), the aims from this study are determine the impact strength of composite and determine the bending strength of composite rice husk charcoal and then find out the sound absorption power of rice husk charcoal composite. Value of impact result revealed that the highest average at 40% fraction of 0.009 j/mm^2 with 1.217 j of energy absorption and the lowest at 60% fraction of 0.007 j/mm^2 with energy absorbing 0.885 j. Value of highest bending strength at 40% fraction is 0.65 MPa to 57.89 MPa modulus elasticity, whereas for bending strength the lowest result on fraction 60% that is 0.42 MPa with 24.49 MPa of modulus elasticity. For sound absorption capability of composites resulted by fraction 60% that is 7.99 dB while sound absorption capability of composites coated (sponge and plywood) resulted by fraction 60% that is 10.71 dB.

Nugroho , (2009) , Through his research the impact strength and bending composites fiber hemp tonic with alkali treatment (HaOH) polyester matrix, with race hush Formaldehyde matrix by volume fractions 20%, 30%, 40%, and 50%. The value of impact strength sandwich with alkali treatment is optimum by Vf specimen on skin 20% at Vf core 50% that is 87.9 kg/mm^2 and without alkali treatment, the optimum is Vf specimen on skin 20% at Vf core 40% that is 111.1 kg/mm^2. Whereas, the value of bending strength sandwich by alkali treatment, the optimum result is Vf specimen on skin 50%at Vf core 50% that is 8.2 Mpa and without alkali treatment, the spectrum result by Vf specimen on skin 40% at core 50% that is 10.5 Mpa. That's because the impact strength and bending composite sandwich with alkali treatment has impact strength and bending lower than the composite sandwich without alkali treatment .

Basic Theory

2.1 Composite

Previously, we have known that material or substance consisted of metal, polymer, ceramic and composite. Each material has its own advantages and weakness. Composite is adjective that is mean structure, arrangement or merger. This composite is come from verb “to compose” that is mean to arrange, to compose or to combine. Therefore, the meaning of composite is a material structure that is mixture or combination from two or more materials on macroscopic scale. It is different with alloy or combination that mixing by microscopic. (Jones, 1975)

The advantage of composite material is combining the superior substances from each composer substance. Material properties that resulted from this combination or mixture expected can complete the weakness, which is be exist on the composer material. (Jones, 1975)

2.2 Classification and Composite Material Properties

Composites can be classified by 3 type (Jones, 1975), that are:

1. Fibrous Composites
2. Particulate Composites
3. Laminated Composites

2.3 Sandwich

Sandwich composite is composed of three layers consisting of a flat composite and sheet metal skin as well as the core in the middle. This composite made with an aim to optimal weight efficiency, but has a high stiffness and strength. Therefore, to obtain these characteristics, in the middle between the two skins is set up a core. (Gibson, 1994)

2.4 Matrix

In the manufacture of a composite, the matrix functions as a binder of reinforced material also as a protective particle from damage by environmental factors. Some matrix materials can provide the required properties as plasticity and toughness. In this study matrix used was Fox glue (PVAC) which is a type of thermosetting matrix. PVAc matrix can be made use of hand lay-up process to the complex process that is the mechanical processes, such as: vacuum bag, press mold and injection mold (Gibson, 1994) In the manufacture of a composite, the matrix serves as a binder material and also as a protective reinforcement particles from damage by environmental factors. Some matrix materials can provide the required properties as plasticity and toughness. The use of PVAc matrix can be done by hand lay-up to the complex process that is mechanical process, such as vacuum bag, press mold and injection mold. (Gibson, 1994)

2.5 Fiber Volume Fraction

The volume fraction can be calculated using following equation:

$$vf = \frac{{wf}/{\rho f}}{{wf}/{\rho f} + {wm}/{\rho m}} \times 100\% \text{................(1)}$$

Where:

vf = volume fraction (gr/cm3)

wf = weight of fiber (gr)

ρf = density of fiber (gr/cm3)

wm = weight of resin (gr)

ρm = density of resin (gr/cm3)

2.6 Water level Testing

This test is to determine the value of water density on the powder of coconut shell charcoal. This test aim to maintain the powder still in water density scale about 8% - 10%. This testing using digital wood moisture contain device.

2.7 Density Testing

Density testing is physical properties test of the specimen, which aims to determine the value of the mass density of the specimens tested. Mass density of a substance is the mass per unit volume.(Barsoum, 1997)

As for the relation of density equation in accordance to Archimides theory can seen at following equation (Barsoum, 1997):

$$\rho = \frac{mair}{mair - mwater} \times \rho water \text{.......(2)}$$

Where:

m_{air} = specimen mass in the air (gr)

m_{water} = specimen mass in the water (gr)

ρ_{water} = Density of water (gr/cm3)

ρ = Density of specimen (gr/cm3)

2.8 Impact Testing

The principle of this test is if the specimen given sudden or surprise load, so the material will experience process of energy absorption so that occurs plastic deformation that cause a fracture. This test specimen formed according to ASTM D 256-00 which then do the impact test by charpy method.

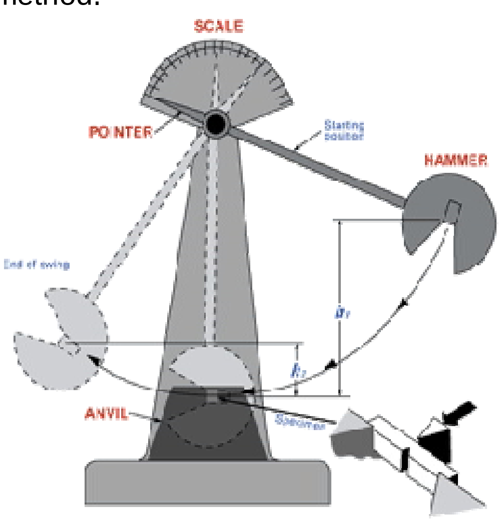


Figure 1. Impact testing scheme (Callister, 2007)

Impact testing can be calculated using equation (Standard ASTM D 256-00):

$E_{absorption}$ = initial energy – remaining energy
= m.g.h – m.g.h'
= m.g (R – R.cosα) – (R – R.cosβ)
= m.g.R (cosβ - cosα)…………………....(3)

Where:
$E_{absorption}$ = Absorption energy (J)
M = pendulum mass (kg)
g = gravity (m/s^2)
R = length of arm or sleeve (m)
α=pendulum angle before wayed
β = pendulum angle after fracture the specimen

Impact number can be calculated using equation:

$$HI = \frac{Eabsorption}{A0} \quad \text{……………………....(4)}$$

Where:
HI = Price impact (J/mm^2)
$E_{absorption}$= absorption energy (J)
A_0= cross section under the notch (mm^2)

2.9 Bending Testing (Three Point Load)

This test aims to determine the bending strength of the composite material. The test conduct by giving the bending load slowly until the specimen fractures. In the treatment of bending test specimens, the top of the specimen occurred press and tensile in the bottom so the effect of bending test is fracture in the bottom because cannot resist the tensile stress.

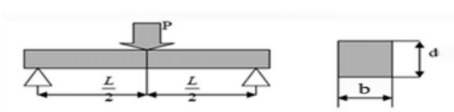


Figure 2. Bending Testing Section (Standard ASTM D 790-02)

Bending strength of the composite material can be determined by the following equation (ASTM D 790-02):

$$\sigma b = \frac{3.P.L}{2.b.d^2} \quad \text{…………………………..…..(5)}$$

While the bending modulus of elasticity calculation using the following formula equation (standard ASTM D 790-02):

$$Eb = \frac{P.L^3}{4.b.d^3.\delta} \quad \text{………..................…..(6)}$$

Where:
σ_b = bending strength (MPa)
E_b = modulus elasticity (MPa)
P = load (N)
L = support span (mm)
b = specimen width (mm)
d = specimen thick (mm)
δ = deflection (mm)

2.10 Sound Absorption Test

Sound absorption test specimens established according to standards of ANSI S1.13 then testing of sound absorption conduct using a sound level meter testing instruments. The tests conducted at room soundproof Lab. Acoustics Architectural Engineering UMS with five seconds method with a reading time of 60 seconds (one minute). The principle of the test was to determine the value of sound absorption that resulting from the composite with various volume fraction.

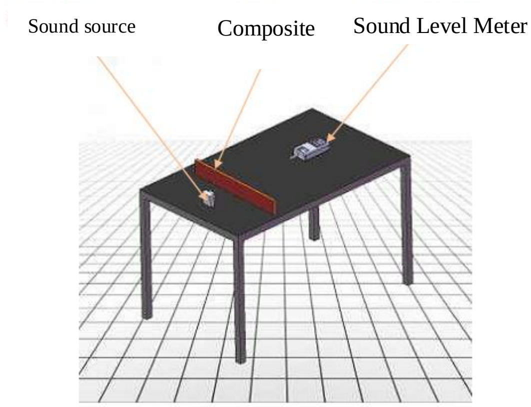


Figure 3. Sound Absorption Test Section (Standard ANSI S1.13)

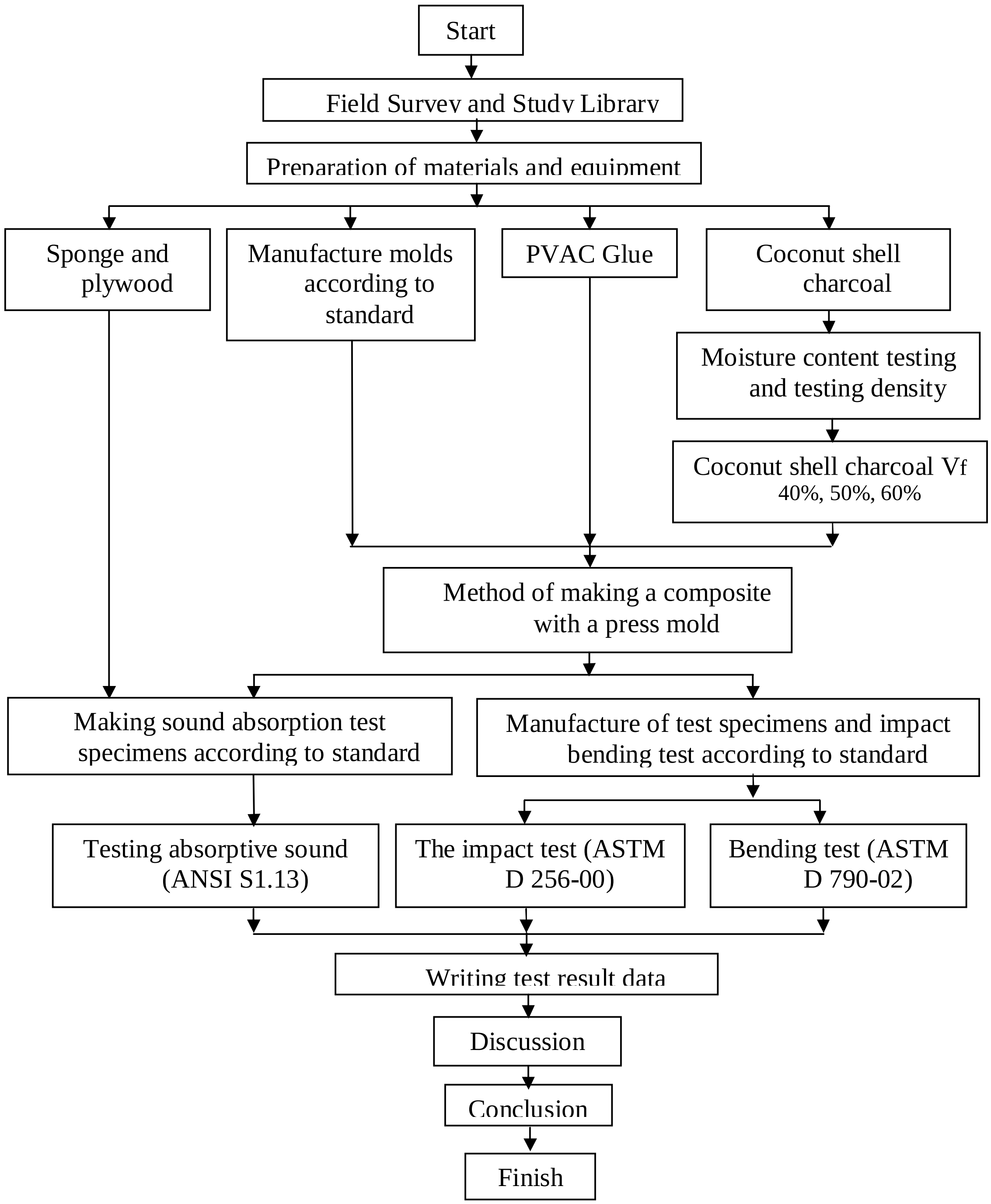
The formulation is derived as follows:

$$\mathbf{L_t = 10 \log \left[\frac{1}{N}\left(\sum N \times 10^{\frac{li}{10}}\right)\right]} \quad \text{...............(7)}$$

Where:
Lt = average sound intensity (dB)
li = interval value average (dB)

METHODS

3.1 Flowchart of Research



3.2 Preparation Material of Composite Manufacturing

Materials used in this study are as follows:

a. Coconut shell charcoal powder
Coconut shell charcoal in the first drying until water content is known to be 8-10%. Coconut shell charcoal is used to create a composite thickness of 20mm. By using a microscope, it is known diameter of coconut shell charcoal powder. Of the test results, the average diameter of the powder obtained by 11.98μm.

Figure 4. Coconut Shell Charcoal

b. Fox glue (PVAc)
The type of fox glue (PVAc) that used is D 150/5 and this matrix is white.

Figure 5. Fox Glue

c. Sponge and plywood
Sponge and plywood used is a sheet with size 50cm x 30cm.

Figure 6. Sponge and Plywood

3.3 Tools Preparation

The tools used in this study are:

a. Water Content Test Device
Water content test device used to measure the moisture content of coconut shell charcoal.

Figure 7. Water Content Test

b. Digital Scales
Digital scales are the scales used to weigh the powder of coconut shell charcoal and fox glue matrix (PVAC).

Figure 8. Digital Scales

c. Specimen dies
1. Sound Absorption dies
Dies are used for sound absorption tests are made of sheet plate with a length of 1000 mm, width 500 mm, thickness 3 mm and in the bulkhead into 3 sections with 33 mm size of the plate length.

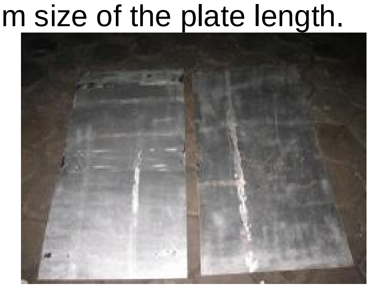


Figure 9. Sound Absorption Dies

2. Mechanical Test Dies
The dies made from teak wood. The size of 150x40x60 mm used for impact test, whereas for bending test is 150x60x60 mm.

Figure 10. Mechanical Test Dies

d. Tool presses of dies
   This press mold is used to help the manufacturing process of composite. The press tool made of metal with diagonal of 40x40 mm.

Figure 11. Tool Pres of Dies

e. Other Tolls
   These tools are used to assist the process of composites manufacturing. These tools consist of bucket, stirrer, scissors, knives, cater, brushes, spoons, rulers, markers and kits pasta.

Figure 12. Other Tool

f. Bending Test Tool
   The tools used to perform the bending test of composites are Universal Testing Machine.

Figure 13. bending test Tool

g. Impact Test Tool
   Charpy impact test tool. This tool is used to perform impact test of composites.

Figure 14. Impact Test Tool

h. Sound Level Meter
   Sound level meter is a device used to test the sound absorption.

Figure 15. Sound Level Meter

RESULTS AND DISCUSSION

4.1 Impact Test

The composite impact test use charpy method that is done by making the specimen in accordance with the standard ASTM D 256-00.

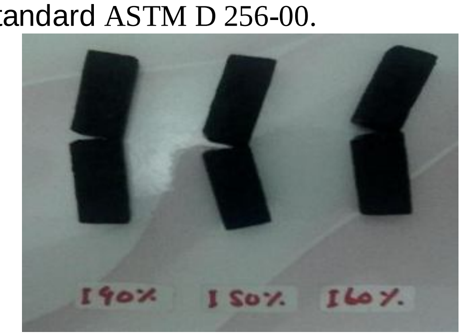


Figure 16. Impact test Result

No	Spec	E absorption (J)	E the average absorption (J)	Price Impact (J/mm)	PI averg (J/mm)
1		1.411		0.0106	
2	40%	1.245	1.328	0.0094	0.0100
3		1.328		0.0100	
4		0.996		0.0074	
5	50%	1.078	1.023	0.0081	0.0076
6		0.996		0.0074	
7		0.913		0.0070	
8	60%	0.913	0.885	0.0068	0.0063
9		0.830		0.0061	

Table 1. Impact Test

From the table above can be created histogram from average energy absorption and the average impact value composite coconut shell charcoal powder with various volume fractions of 40%, 50% and 60% with PVAC glue matrix.

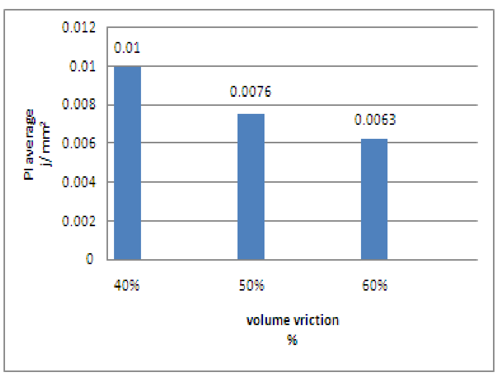


Diagram 1. average energy absorption and the average impact value composite coconut shell charcoal powder

In the histogram above shows that the highest average at impact number is 40% volume fraction of 0.0100 J / mm ² and the lowest average impact number is 60% volume fraction of 0.0063 J / mm ²

4.2 Bending Test

Bending test conducted with a Three-point bending test standard ASTM D 790-02.

Figure 17. Bending Test Result

No	Spes	Span (mm)	bending stress (MPa)	average stress (MPa)	modulus elasticity (MPa)	average modulus (MPa)
1		100	0.58		52.24	
2	40%	100	0.58	0.62	53.4	55.66
3		100	0.69		61.35	
4		100	0.58		40.73	
5	50%	100	0.46	0.54	34.33	38.83
6		100	0.58		41.43	
7		100	0.46		26.7	
8	60%	100	0.35	0.38	19.75	22.25
9		100	0.35		20.3	

Table 2. Bending Test

From the table above can be created histogram average bending stress and average modulus of elasticity of coconut shell charcoal composites with various volume fractions of 40%, 50% and 60% with PVAC glue matrix.

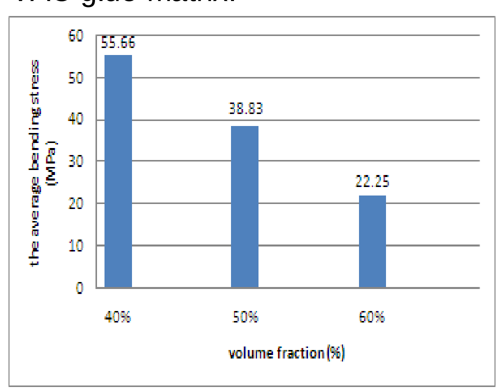


Diagram 2. average energy absorption and the average impact value composite coconut shell charcoal powder

In the histogram above shows that the highest average modulus of elasticity is at 40% volume fraction of 55.66 MPa and the lowest average modulus of elasticity is at 60% volume fraction of 22.25 MPa.

4.3 Sound Absorption Test

Sound absorption testing is done with a sound level meter testing instruments to test the specimens by the method of five seconds (five-second method) with a reading time 1 minute.

1. The data result with the specimen of coconut shell charcoal powder composite.

Figure 18. Specimen of coconut shell charcoal powder composite to sound absorption test.

No.	Spes.	Free space with the sound source (dB) A	Sound intensity (dB) B	Sound absorption capacity (dB) (A-B)	((A-B)/A)*100% (%)
1	40%	79.27	78.99	0.28	0.35%
2	50%	79.27	76.99	2.28	2.88%
3	60%	79.27	75.99	3.28	4.13%

Table 3. Data result with the specimen of coconut shell charcoal powder composite.

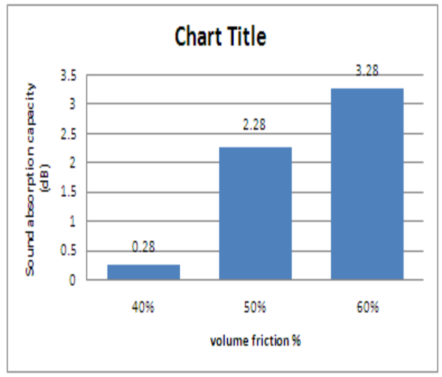


Diagram 3. Data result with the specimen of coconut shell charcoal powder composite.

In the histogram above shows that the highest ability of the sound absorption materials is at 60% volume fraction of 3.28 dB and the lowest ability of sound absorption material is at 40% volume fraction of 0.28 dB.

2. The data result with layered composite specimen (sponge and plywood) of coconut shell charcoal powder.

Figure 19. Layered composite specimen (sponge and plywood) of coconut shell charcoal powder to sound absorption test.

No.	Spes.	Free space with the sound source (dB) A	Sound intensity (dB) B	Sound absorption capacity (dB) (A-B)	((A-B)/A)*100% (%)
1	40%	79.27	68.36	10.91	13.76
2	50%	79.27	66.81	12.46	15.71
3	60%	79.27	66.15	13.12	16.55

Table 4. Data result with layered composite specimen (sponge and plywood) of coconut shell powder.

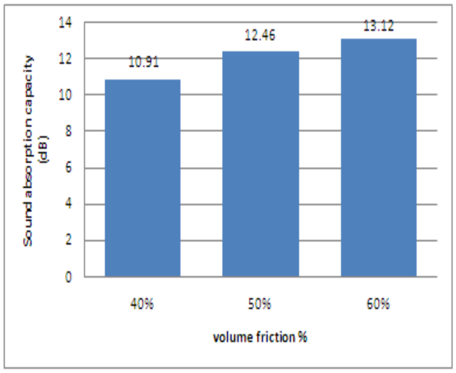


Diagram 4. Data result with layered composite specimen (sponge and plywood) of coconut shell powder.

In the histogram above shows that highest sound absorption capability of layered composite specimen (sponge and plywood) is at 60% volume fraction of 13.12 dB and the lowest is at 40% volume fraction of 10.91 dB.

CLOSING

5.1 Conclusion

1. For the result of impact test obtained that the highest impact strength is coconut shell charcoal powder composites with volume fractions of 40%, while the lowest is the rice husk charcoal powder composites with volume fraction of 60%.
2. From the data of bending test can be concluded that the highest bending strength is a composite with volume fraction of 40% and the lowest is the composite with volume fraction of 60%.
3. From the result of research showed that the highest sound absorption capability of composite specimen (coconut shell charcoal powder) is at volume fraction of 60%, while the lowest sound absorption capability of composite specimen (coconut shell charcoal powder) is at volume fraction of 40%.

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